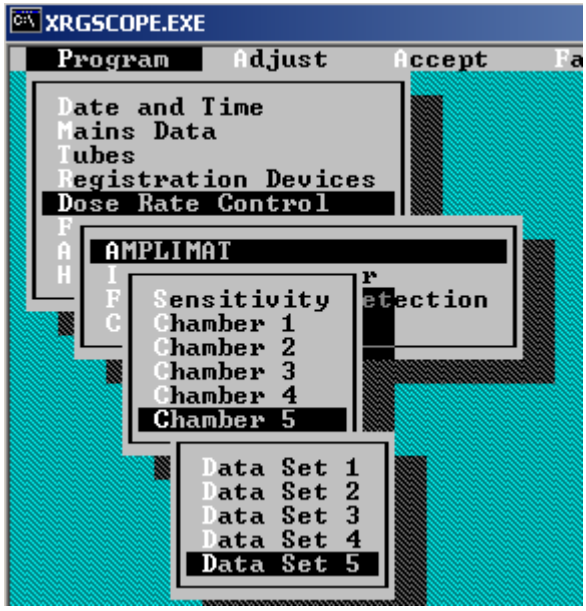
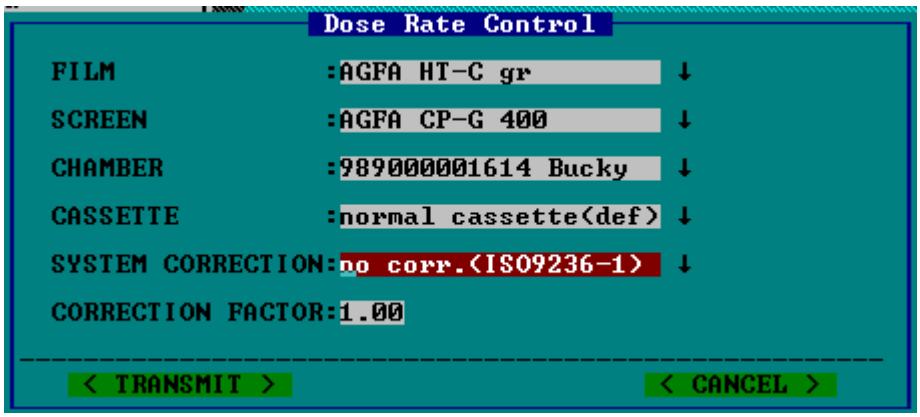
Calculation process of Film – Screen – Combinations

To program a film-screen-combination (FSC) one selects (at Optimus RAD – R/F, screen looks a little different at Optimus C)

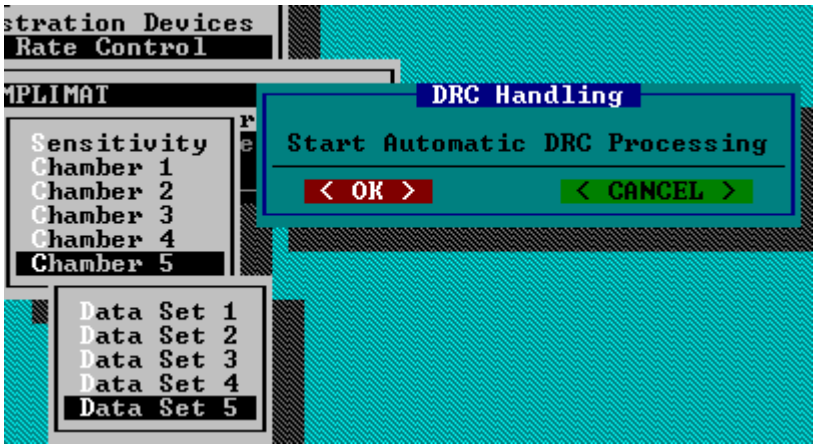


and enters the existing components on site in the following screen:

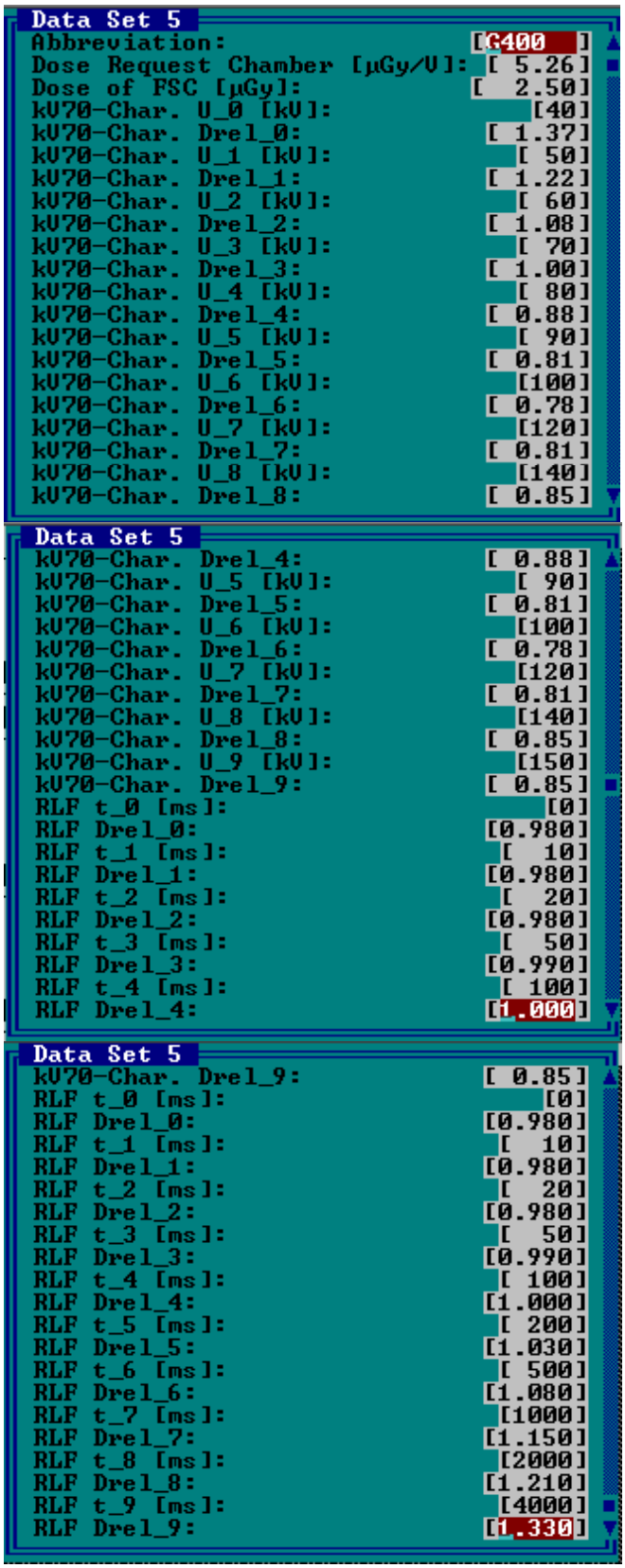


With these data one gets the basic setting.
AEC (automatic exposure control) as exposure technique and DRC (dose rate control) as function unit in the generator will act on the kV dependent behavior of the FSC which is calculated during the <TRANSMIT> process to the generator.

The result of the calculation can be seen in the data set screen if one calls the same function again, but instead of >ENTER> one hits the <ESC> key or the <TAB> and selects <CANCEL>.



The data screen with the calculated values (divided in 3 to see all values):



```
Data Set 5
Abbreviation:                          [G400    ]
Dose Request Chamber [µGy/V]:          [ 5.26]
Dose of FSC [µGy]:                     [  2.50]
kV70-Char. U_0 [kV]:                      [40]
kV70-Char. Drel_0:                     [ 1.37]
kV70-Char. U_1 [kV]:                      [ 50]
kV70-Char. Drel_1:                     [ 1.22]
kV70-Char. U_2 [kV]:                      [ 60]
kV70-Char. Drel_2:                     [ 1.08]
kV70-Char. U_3 [kV]:                      [ 70]
kV70-Char. Drel_3:                     [ 1.00]
kV70-Char. U_4 [kV]:                      [ 80]
kV70-Char. Drel_4:                     [ 0.88]
kV70-Char. U_5 [kV]:                      [ 90]
kV70-Char. Drel_5:                     [ 0.81]
kV70-Char. U_6 [kV]:                     [100]
kV70-Char. Drel_6:                     [ 0.78]
kV70-Char. U_7 [kV]:                     [120]
kV70-Char. Drel_7:                     [ 0.81]
kV70-Char. U_8 [kV]:                     [140]
kV70-Char. Drel_8:                     [ 0.85]
```

```
Data Set 5
kV70-Char. Drel_4:                     [ 0.88]
kV70-Char. U_5 [kV]:                      [ 90]
kV70-Char. Drel_5:                     [ 0.81]
kV70-Char. U_6 [kV]:                     [100]
kV70-Char. Drel_6:                     [ 0.78]
kV70-Char. U_7 [kV]:                     [120]
kV70-Char. Drel_7:                     [ 0.81]
kV70-Char. U_8 [kV]:                     [140]
kV70-Char. Drel_8:                     [ 0.85]
kV70-Char. U_9 [kV]:                     [150]
kV70-Char. Drel_9:                     [ 0.85]
RLF t_0 [ms]:                             [0]
RLF Drel_0:                            [0.980]
RLF t_1 [ms]:                             [  10]
RLF Drel_1:                            [0.980]
RLF t_2 [ms]:                             [  20]
RLF Drel_2:                            [0.980]
RLF t_3 [ms]:                             [  50]
RLF Drel_3:                            [0.990]
RLF t_4 [ms]:                             [ 100]
RLF Drel_4:                            [1.000]
```

```
Data Set 5
kV70-Char. Drel_9:                     [ 0.85]
RLF t_0 [ms]:                             [0]
RLF Drel_0:                            [0.980]
RLF t_1 [ms]:                             [  10]
RLF Drel_1:                            [0.980]
RLF t_2 [ms]:                             [  20]
RLF Drel_2:                            [0.980]
RLF t_3 [ms]:                             [  50]
RLF Drel_3:                            [0.990]
RLF t_4 [ms]:                             [ 100]
RLF Drel_4:                            [1.000]
RLF t_5 [ms]:                             [ 200]
RLF Drel_5:                            [1.030]
RLF t_6 [ms]:                             [ 500]
RLF Drel_6:                            [1.080]
RLF t_7 [ms]:                            [1000]
RLF Drel_7:                            [1.150]
RLF t_8 [ms]:                            [2000]
RLF Drel_8:                            [1.210]
RLF t_9 [ms]:                            [4000]
RLF Drel_9:                            [1.330]
```

Only two items should be modified in this data screen, **ALL OTHERS MUST NOT BE CHANGED**.

If the name of the FSC shall be changed one can do it in the

```
Abbreviation:                          [G400    ]
```

line [name] field.

The desired density according to the customers taste will be programmed in the

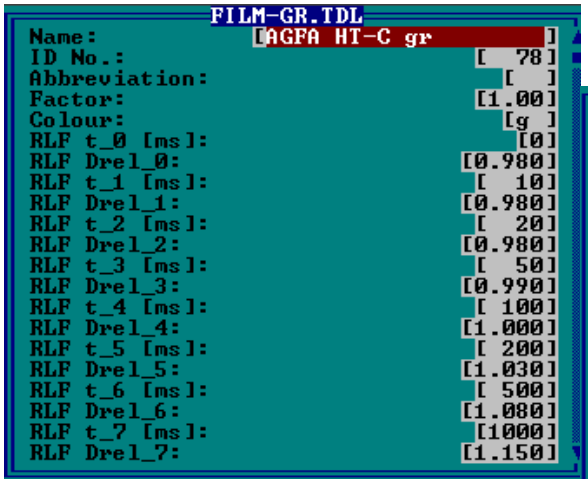
line [value] field afterwards.

These are the activities which are usually carried out at a system to get pictures exposed with a density which should be linear throughout the entire kV range … using AEC techniques.

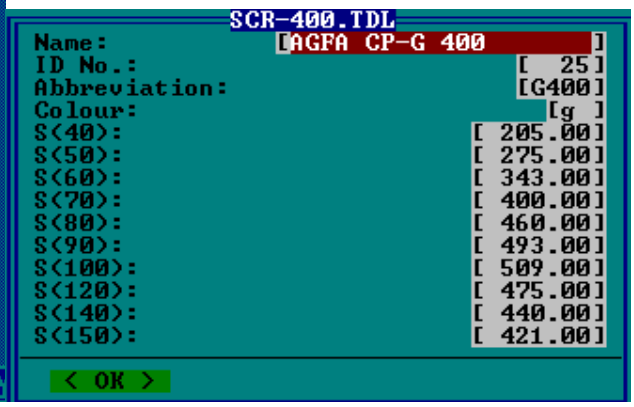
How is the calculation done ?

Basic table data of

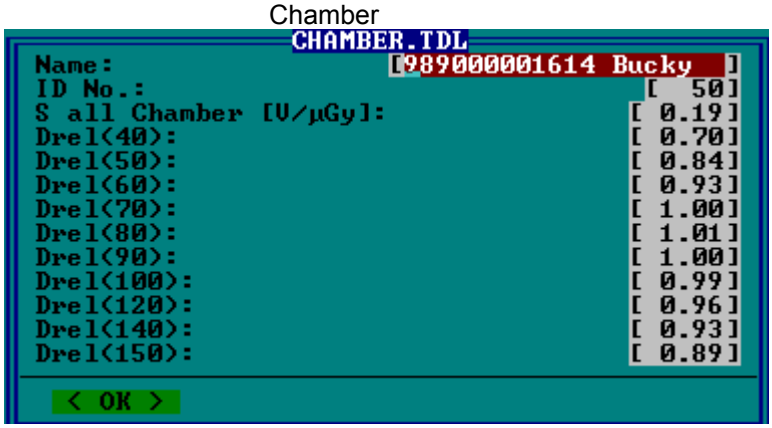
Film



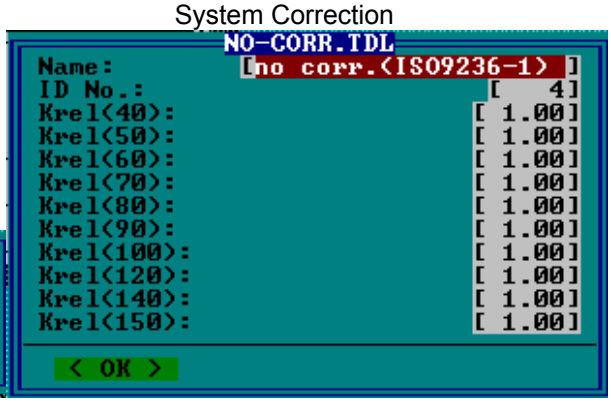
Screen



Chamber



System Correction



Cassette

as selected and programmed in the “Dose Rate Control” screen are either

- simply taken as they are
or
- are multiplied with others.

Default data are bold, *calculated values italic*.

kV	FILM	SCREEN	CHAMBER	CASSETTE	SYSTEM CORRECTION	CORRECTION FACTOR	*calculated values for exposure*
40	no affecting factors	**205**	**0.70**	no affecting factors	**1**	no affecting factors	*1.37*
50		**275**	**0.84**		**1**		*1.22*
60		**343**	**0.93**		**1**		*1.08*
70		**400**	**1.00**		**1**		*1.00*
80		**460**	**1.01**		**1**		*0.88*
90		**493**	**1.00**		**1**		*0.81*
100		**509**	**0.99**		**1**		*0.78*
120		**475**	**0.96**		**1**		*0.81*
140		**440**	**0.93**		**1**		*0.85*
150		**421**	**0.89**		**1**		*0.85*
RLF [ms]		no affecting factors	no affecting factors	no affecting factors	no affecting factors	no affecting factors	
0	**0.98**						*0.98*
10	**0.98**						*0.98*
20	**0.98**						*0.98*
50	**0.99**						*0.99*
100	**1.00**						*1.00*
200	**1.03**						*1.03*
500	**1.08**						*1.08*
1000	**1.15**						*1.15*
2000	**1.21**						*1.21*
4000	**1.33**						*1.33*
	1	*2.5µGy*		**1**		**1**	*2.5 µGy*
	basic dose of FSC and its possible correction factors						
			0.19V/µGy or *5.24µGy/V* basic chamber sensitivity				*5.24 µGy/V*

RLF factors are only recognized if the actual exposure time prediction gets into the time range and will then influence the exposure duration.

Curves of all non-linear-kV components for the calculation process have a basic value or factor at 70kV as reference to start with, the RLF (reciprocal law failure) reference time value is 100ms.

SCREEN
Screen speed classes are specified at 70kV, which means that the AGFA CP-G 400 screen in this example is a 400 speed version.
It is the screen determining the speed class of a cassette. Only a few films have such a low sensitivity that they decrease the speed class of an FSC.

The chemistry or luminescent group of the screen determines the speed / sensitivity at kV values between 40…150kV.
The AGFA CP-G 400 screen (luminous group 1, see booklet Radiographic screens and films 4512 980 50592 available on Intranet) has e.g. a speed of 205 at 40kV.
Relatively seen to the 70kV speed of 400 it requires almost double of the dose to achieve the same density.
At 100kV it has its highest sensitivity table value with 509.

The required dose for an exposure to get a basic density of 1.00 follows the formula (400 in this case)

$$\frac{1000\ \mu Gy}{\text{speed class}} = \frac{1000\ \mu Gy}{400} = 2.5\ \mu Gy$$

The dose requirement for other kV stages is a different one, the relative factor is calculated

400 (70kV)
---------- = 1.95 = relative screen factor
205 (40kV)

At 40kV the FSC requires a dose of 2.5 µGy x 1.95 = 4.874 µGy for a density of 1.00.

CHAMBER
The Amplimat measuring chamber with its non-linear kV behavior has a certain dose request at 70kV (5.24 µGy/V in this example) to provide 1V of chamber voltage. It is used in the generator to terminate the exposure once the actual density voltage value achieved the calculated setpoint value.
The density voltage "U_off" is calculated depending on the kV and all other selected items.

At 40kV the chamber requires only 0.70 times or 70% of the 70kV dose to achieve the same chamber voltage. It is the relative factor referring to 70kV = 1.

U_off calculation
U_off is the density voltage, which is the setpoint for the comparator terminating the exposure once the actual value of the signal from the chamber achieved the setpoint.
It is not an analogue comparator, "dose rate control" is a digital circuit even though it is fed by analogue Amplimat chamber signals.

If the relative 40kV factors of the screen and the chamber are multiplied one gets

1.95 [screen] x 0.70 [chamber] = 1.37

which one can read in the *"calculated values for exposure"* column of the table on the previous page.

The 70kV chamber sensitivity is 5.24 µGy / V.
The dose for an individual exposure with a 400 speed system is 2.5 µGy (at 70kV).

$$U\_off = \frac{\text{exposure dose}}{\text{chamber sensitivity}} = \frac{2.5\ \mu Gy}{5.24\ \mu Gy}\ V = 0.477\ V$$

U_off will be calculated by the 70kV value multiplied with the selected kV correction value from the table.

data calculation based on a straight 400 speed system = 2.5 µGy / exposure and all factors of **Film / Cassette / Correction Factor = 1.00**						
kV	SCREEN	*relative screen factor*	CHAMBER	SYSTEM CORRECTION	*calculated values for exposure*	*U_off* [V] see 40/70/100kV examples next page
40	**205**	*1.95*	**0.70**	**1**	*1.37*	*0.653*
50	**275**	*1.45*	**0.84**	**1**	*1.22*	*0.582*
60	**343**	*1.17*	**0.93**	**1**	*1.08*	*0.515*
70	**400**	*1.00*	**1.00**	**1**	*1.00*	*0.477*
80	**460**	*1.15*	**1.01**	**1**	*0.88*	*0.420*
90	**493**	*1.23*	**1.00**	**1**	*0.81*	*0.386*
100	**509**	*1.27*	**0.99**	**1**	*0.78*	*0.372*
120	**475**	*1.19*	**0.96**	**1**	*0.81*	*0.386*
140	**440**	*1.10*	**0.93**	**1**	*0.85*	*0.405*
150	**421**	*1.05*	**0.89**	**1**	*0.85*	*0.405*

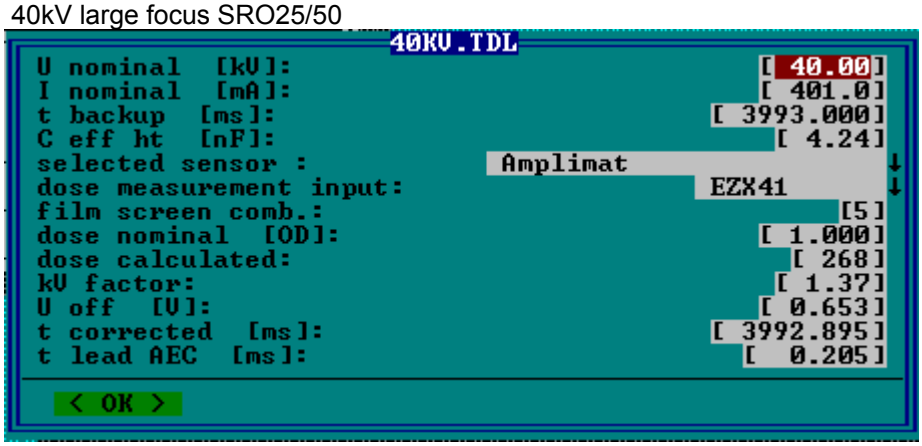
A modification of the basic 

value will shift the entire curve and with it the density up or down.

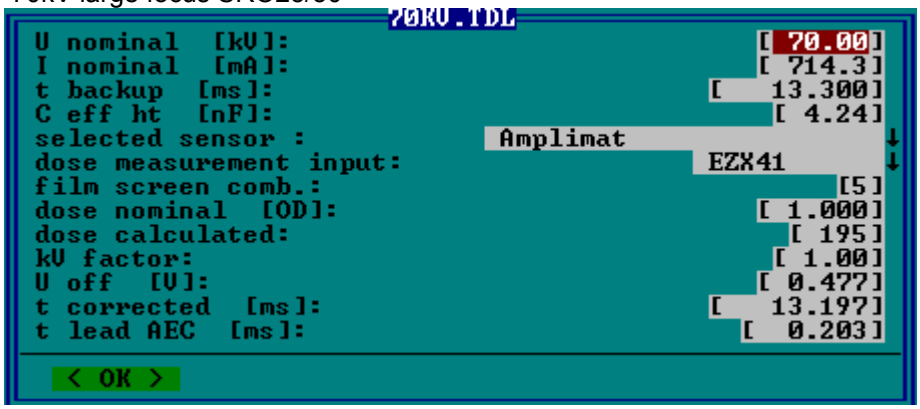
The dose ramp to see if the generator terminates the exposure at the given U_off value (see screenshot examples next page) can be monitored with an oscilloscope at PCB EZ150 X4 and X5.

Examples of calculated U_off values:

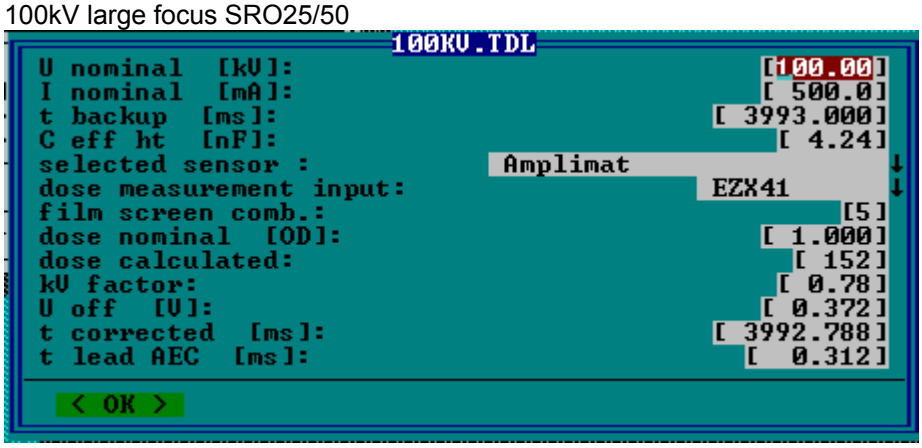
40kV large focus SRO25/50



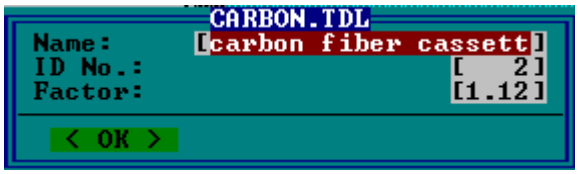
70kV large focus SRO25/50



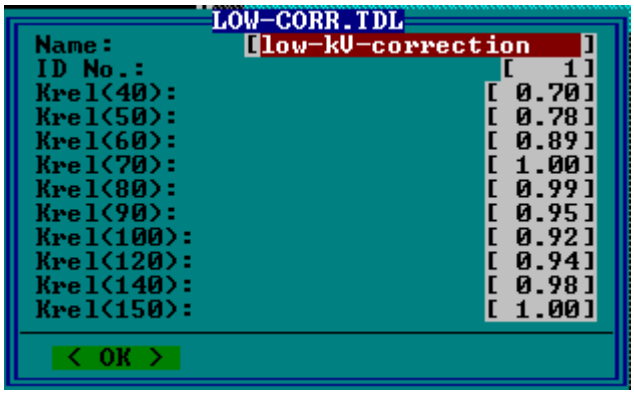
100kV large focus SRO25/50



If films are used in a carbon fiber cassette the attenuation is lower compared to the standard Aluminum cassette (default factor 1).
All calculated values are divided by the factor of 1.12 if a carbon fiber cassette is programmed.



Some FSC's might require an additional reduction of the dose to get a linear density throughout the lower the kV values. Then the low kV correction must be programmed.



producing the following calculation table:

data calculation based on a straight 400 speed system = 2.5 µGy / exposure, factors of **Film / Cassette = 1.00**						
kV	SCREEN	*relative screen factor*	CHAMBER	SYSTEM CORRECTION	*calculated values for exposure*	*U_off* [V]
40	**205**	*1.95*	**0.70**	**0.70**	*0.96*	*0.457*
50	**275**	*1.45*	**0.84**	**0.78**	*0.95*	*0.454*
60	**343**	*1.17*	**0.93**	**0.89**	*0.96*	*0.458*
70	**400**	*1.00*	**1.00**	**1.00**	*1.00*	*0.477*
80	**460**	*1.15*	**1.01**	**0.99**	*0.87*	*0.416*
90	**493**	*1.23*	**1.00**	**0.95**	*0.77*	*0.367*
100	**509**	*1.27*	**0.99**	**0.92**	*0.72*	*0.342*
120	**475**	*1.19*	**0.96**	**0.94**	*0.76*	*0.363*
140	**440**	*1.10*	**0.93**	**0.98**	*0.83*	*0.397*
150	**421**	*1.05*	**0.89**	**1.00**	*0.85*	*0.405*